CHAPTER 8

TESTING

8.1 INTRODUCTION

by Humphrey Gilbert, a Manhattan Project safety engineer who coined the term "HEPA filter." The heart of the filter is the media (paper), originally the same filter paper used in WWII-era military gas mask canisters. As a result, the HEPA filter inherited many of the same specifications used for the gas mask military standards, most of which were developed during WWII and have remained largely intact to the present. For example, HEPA filters are tested for efficiency using aerosols with a 0.3-μm particle size because academics in the 1940s calculated that a particle of that size would be the most difficult to capture or filter. Modern technology has proven this calculation highly accurate.

Testing of high-efficiency nuclear air cleaning systems is required to achieve and maintain high performance and continual safe operation of nuclear facilities. In nonreactor nuclear facilities throughout the U.S. Department of Energy's (DOE) complexes, HEPA filters in confinement ventilation systems can be constantly challenged with radioactive aerosols. Nonreactor nuclear facilities comprise the bulk of DOE's nuclear facilities, and failure of their air cleaning system components can lead to uncontrolled release of radioactive aerosols. Thus, maintaining nuclear facility operability depends on the performance of these air cleaning components.

At the same time, HEPA filters and absorbers were being developed for nuclear application, methodologies were being developed to assure the performance of these components. These methodologies eventually evolved to form a performance assurance program with three major components: (1) design qualification of individual components through destructive testing, (2) quality assurance of individual components through nondestructive testing, and (3) performance assurance of nuclear confinement ventilation systems through in-place testing. The overall performance assurance program was designed to be hierarchical because components were built on a foundation laid down by preceding components. Design qualification assured that those filters produced according to a manufacturer's design met specific performance criteria for normal and off-normal operation. Ideally, these performance criteria were directly derived from a facility's authorization basis document. In fact, this was often was not the case, making it difficult to impossible to crosswalk facility operation requirements with material/design qualification test criteria.

Once a manufacturer's design is qualified, the filter model number was put on a qualified products list (QPL) maintained by the Department of the Army. This list was used by nuclear facilities to procure qualified filters. Since the withdrawal of MIL 51068[20] and 51079[29], the Army no longer maintains the QPL. Manufacturers simply receive a letter stating the filters they submitted passed the test. The Army does not include model number information in these letters. Filters ordered by a nuclear facility are quality assurance-tested by the manufacturer. Filters destined for DOE nuclear facilities typically have been sent to the DOE Filter Test Facility (FTF) for acceptance testing. Only filters that pass the FTF tests are forwarded to a DOE nuclear facility. Filters that fail are returned to the manufacturer. To date, and for the past 40 years, quality assurance FTF testing was required for all filters used in DOE facilities (including those of its predecessor agencies). In August 1978, based on the review of the FTF operational data, the U.S. Nuclear Regulatory Commission (USNRC) no longer recommended verification testing of filters. As a result, filters for nuclear power plants are not sent to the FTF for quality assurance testing.

After being installed at the nuclear facility, an in-place leak test is performed to assure the performance of the confinement ventilation system. Specific objectives of in-place filter testing[1] are (1) to test the aggregate performance of filters in a filter bank, (2) to evaluate the effectiveness of seals between the filter gasket and the filter housing, (3) to assess the leak tightness of the filter plenum, and (4) to determine whether bypasses exist around the filter plenum.

In this chapter each of the components of the performance assurance program are described, with a chapter section devoted to each component. The final section of the chapter discusses needed research in the area of nuclear air cleaning component performance assurance.

8.2 PROOF OF DESIGN - HEPA FILTER QUALIFICATION FOR NUCLEAR SERVICE

Systematic quality control and quality assurance testing are conducted at all stages of the product cycle, from development to use. HEPA filters for nuclear service undergo three qualification routines: (1) a first qualification test performed by a qualified laboratory (the U.S. Army's Edgewood Arsenal) to place the filter on the QPL, (2) a second test at the place of manufacturer, and (3) a third at the place of utilization. In addition, DOE requires a fourth qualification procedure that is unique to that agency.

The former QPL performance testing is now a requirement of ASME AG-1, Section FC.[3] It examines areas such as media penetration, resistance to airflow, resistance to rough handling, resistance to pressure, resistance to heated air, spot flame resistance, environmental conditions, and cyclic exposure. The filter medium receives the most rigorous and extensive control and evaluation.

The manufacturer's qualification procedure involves two distinct phases: (1) a quality assurance/quality control (QA/QC) routine intended to assure careful manufacture of a quality product and (2) a series of tests to verify filter compliance with preset standards concerning the properties of components, the physical characteristics of the assembled filter, and a set of performance criteria related to collection efficiency and resistance to air flow. When all of these factors are within the tolerance limits set by the applicable standards, the manufacturer certifies that each delivered filter unit meets all acceptance criteria.

The qualification that occurs at the using installation is known as the in-place leak test. This test is conducted according to a standard protocol after the installation of clean, new filters to provide assurance that the filter units have been installed correctly in a leak-free filter-holding framework and that the filter units suffered no damage during shipping or installation. The test is essentially a search for defects, not an additional filter efficiency test.

The extra qualification step mandated by DOE involves thorough visual inspection and testing of all purchased filters for compliance with required physical characteristics as well as for efficiency and airflow resistance at the DOE-supported FTF before release to the using agency. Filters failing to meet all applicable criteria are rejected at that point and are returned to the manufacturer for credit. Neither DOE nor the USNRC permit repairs of filters intended for nuclear service. [2]

8.2.1 QUALIFIED PRODUCTS LIST - HEPA FILTERS

As discussed previously, the U. S. Army Edgewood Arsenal developed military standards for HEPA filters and a QPL based on exhaustive tests of the manufacturers' filter media and filters. This facility also performed the QPL testing and began QA testing of HEPA filters. It was mandated that only QPL-listed manufacturers could be used for HEPA filter procurement. The nuclear industry adapted the QPL for its use in procuring HEPA filters. Available American Society for Testing and Materials (ASTM), Technical Association of the Pulp and Paper Industry (TAPPI), and other standard test procedures and equipment were referenced in the documentation of QPL products. Numerous organizations have issued consensus standards incorporating major provisions of the military specification and qualification standards. Those holding the most interest for nuclear service